

Australasian Plant Conservation

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A snapshot of biosecurity policy at the Australian Government Department of Agriculture
Hawkweeds: modelled invasion of Tasmania and eradication in the Victorian Alps
Native woody weeds jump the fence at the Australian National Botanic Gardens
Tomato Red Spider Mite and Asian Woolly Hackberry Aphid
The trouble with Sweet Pittosporum
And much much more ...

SPECIAL THEME: INVASIVE SPECIES AND BIOSECURITY

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Front cover: A volunteer seeks hawkweed (*Hieracium* spp.) in a detection experiment. Three species of Hawkweed—Orange (*Hieracium aurantiacum*), Mouse-ear (*H. pilosella*) and King Devil (*H. praealtum*)—have established small populations in the Falls Creek Alpine Resort and surrounding areas of Victoria's Alpine National Park. The ability of hawkweeds to spread rapidly and disrupt floristic communities, as well as their passing resemblance to native daisy species and occurrence in steep terrain present difficult challenges to plant conservationists. Photo: Roger Cousens.

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From the editor

Huw Morgan

Welcome to the Spring issue of Australasian Plant Conservation. As I sit at the humble editorial computer, a Snowy River Wattle (*Acacia boormanii*) stands just within my field of view. This outrageous individual—silently exploding in bloom—seems to be boldly declaring the end of Canberra’s winter.

The theme of this issue is **Invasive species and biosecurity**. Australia’s spectacular native flora (including the Snowy River Wattle) evolved in a relatively isolated landscape which kept a host of invasive species from having their impact. Today’s global economy and vast transport networks deliver heightened risk of invasive species introductions and there is subsequently a need for increasingly efficient and effective biosecurity controls to be in place.

A focus on invasive species and biosecurity is particularly timely given a couple of issues playing out on the national stage. First, a Senate inquiry into environmental biosecurity was referred on 3 June 2014 to investigate ‘the adequacy of arrangements to prevent the entry and establishment of invasive species likely to harm Australia’s natural environment, including recent biosecurity performance and Australia’s state of preparedness for new environmental incursions’. The Australian Network for Plant Conservation was one of 74 bodies to make a submission to the inquiry, due to

report its findings on 3 December 2014 following public hearings in October and November. Further information on this inquiry, including the 74 submissions, is available via: www.tinyurl.com/Senate-Inquiry

Second, the Australian Government, through its Department of Agriculture has been reforming national biosecurity policy over the past couple of years. This includes the recent (June 2014) adoption of a new National Surveillance and Diagnostics Framework under the Intergovernmental Agreement on Biosecurity. An article in this issue from the Sustainability and Biosecurity Policy Division of the Australian Government Department of Agriculture provides a good introduction to this work.

I’m pleased to present a broad range of articles exploring a diversity of issues on the theme of Invasive species and biosecurity—from invasive species modeling, identification, monitoring, control and eradication programs to national biosecurity and invasive species policies. This issue also contains the first article in a series by **Dan Cole** and **Greg Siepen** to be published over several future issues exploring considerations required in undertaking large-scale reforestation plantings. May you find a quiet corner with your own ‘Snowy River Wattle’ to sit and enjoy this excellent issue!

Biosecurity in Australia: a snapshot of biosecurity policy and initiatives at the Australian Government Department of Agriculture

Sustainability and Biosecurity Policy Division

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Biosecurity underpins our way of life and safeguards the environmental assets we enjoy and value. It also protects Australian farmers from the impacts of serious pests and diseases that can significantly increase production costs and close down markets, both here and overseas. With increased trade, growth in passenger movements, changing climate and global distribution of pests and diseases,

managing biosecurity is becoming more challenging. Managing Australia’s biosecurity system is a big job and involves activities to prevent harmful pests and diseases from entering into Australia; containing and eradicating those that arrive; or putting effective management programs in place should they become established.

Our relative geographical isolation and the absence of shared land borders provide some natural protection from biosecurity threats. However, the biosecurity system is complex, and operates in an environment characterised by the continual movement—in and out of the country—of living things and goods. It is not possible or desirable to manage biosecurity risk to one sector in isolation of another, or without a strong network that includes different levels of government, industry, non-government organisations and the community working together to achieve a common objective—one biosecurity. Zero risk is not achievable—but risk can be effectively managed to a very low level using a risk-based approach.

The Intergovernmental Agreement on Biosecurity

Australian governments have embarked on a number of reforms to make sure the national biosecurity system keeps pace with this changing environment and is sustainable into the future, and one of the principal reforms is delivered under the Intergovernmental Agreement on Biosecurity (IGAB). The IGAB is a Council of Australian Governments (COAG) initiative that came into effect in January 2012. The IGAB establishes a clear vision for building a smarter biosecurity system through improved collaboration between the Australian, state and territory governments. The Australian Government, through Department of Agriculture, plays a central role in managing biosecurity activities offshore and at the border—state and territory governments are responsible for biosecurity matters within their jurisdictions.

The IGAB outlines priority areas to improve how governments do business and work with each other where their responsibilities intersect or where there is benefit in a nationally coordinated approach. The aims of the IGAB are to:

- ensure efforts are risk based and targeted for better outcomes
- improve capacity to respond to exotic pest and disease incursions
- decrease regulatory burden and duplication of activities
- ensure better returns on public funds and at the farm gate.

The IGAB recognises that responsibility for biosecurity does not rest solely with governments. Industry bodies, importers, exporters, farmers, research institutions and the community all play key roles, as do government and industry partnerships. Such partnerships exist through Animal Health Australia and Plant Health Australia. The IGAB identifies opportunities for governments to work together with these parties to manage biosecurity threats.

Improving Australia's biosecurity system under the IGAB

Risk based approach

Biosecurity risk is managed to a very high standard, but zero biosecurity risk is unrealistic given the length of our borders and the mobile nature of today's global economy and population. Zero biosecurity risk would mean zero trade and zero international travel. There are also other risk pathways that we cannot control, such as the wind and ocean currents.

Australia's biosecurity system focuses on targeting what matters most with resources directed towards the pests and diseases that can cause the most harm. This aim is to target risk where it is most effective to do so and reduce the regulatory burden on clients. An example of this approach can be seen in the Australian Government's move from mandatory border intervention targets to a risk-based model, allowing faster clearance of goods at ports and airports for those who comply with biosecurity rules. This effectively cuts costs for industry members who do the right thing.

Other activities include conducting medium and longer term risk analyses, the provision of scientific advice to support pest and disease management strategies, policies around imports and export standards, and reviews of import protocols in response to changes in disease status and technologies around the world.



Bromeliad inspection. Photo courtesy of the Department of Agriculture.

Surveillance and diagnostics

Enhancing national surveillance and diagnostic capability and capacity is a priority area of reform under the IGAB, with a national framework agreed in June 2014. The first step in implementing the National Surveillance and Diagnostics Framework will involve the review of existing arrangements and strategies that are in place for each agricultural sector, so that pests and diseases can be detected early. Where there is no existing strategy, new ones will be developed. This work is underway and will involve consultation with industry and relevant stakeholders, including environment and community sectors.

Managing established pests and diseases

The management of established pests and diseases is an integral part of primary production and natural resource management systems. There are opportunities to re-adjust the way these pests are managed by ensuring activities are undertaken by the most appropriate party. For example, landholders are better placed to manage risks on their own properties as they can identify and implement the most appropriate mechanisms to suit their circumstances. Governments on the other hand could add more value by concentrating their efforts on preventing other pests and diseases from entering the country and establishing. This approach is expected to improve responses to complex pest and disease issues and foster further partnering opportunities. Consultation is underway on this proposal with a discussion paper expected to be released in September 2014.

Weeds and pest animals

Weeds and pest animals pose serious threats to Australia's environment and primary production resource base. Weeds reduce forest productivity, displace native species and contribute to land degradation. They can also have a major impact on the productivity and profitability of farm industries. Measures to control weeds can cost farmers in excess of \$1.5 billion per annum. The cost to biodiversity conservation and landscape amenity has not been quantified.

Governments are working closely with landholders and other stakeholders to improve weed management practices across the country, lessen the burden on farmers and reduce the effect of particular weeds on the environment. This is achieved through national initiatives such as the Australian Weeds Strategy, Landcare, and investment in rural Research and Development Corporations (RDC), the CSIRO and the Plant Biosecurity Cooperative Research Centre.

Pest animals generate similar challenges, with key invasive species (birds, rabbits, wild dogs, mice, foxes and feral pigs) costing major Australian agricultural industries and farm businesses an estimated \$740 million per year in lost productivity and control expenditure.

While pest management is primarily the responsibility of the states and territories, the Australian Government plays a role in coordinating strategic pest animal management, and provides support and funding to the rural RDCs, the Invasive Animals Cooperative Research Centre and for industry-driven initiatives such as the National Wild Dog Plan.

Australian Weeds and Pest Animal Strategies

The Australian Weeds and Pest Animal strategies were developed in 2007 and have been very successful in providing strategic blueprints for the management of weeds and pest animals in Australia. They have been warmly received by governments, researchers, natural resource managers and landholders.

Achievements of the Australian Weeds Strategy include:

- the development of principles to guide collaborative effort and consistent planning across different sectors and levels of government in addressing weed management.
- a prioritisation process for weeds (including those that are nationally significant), providing a cost-effective mechanism for raising community awareness of Australia's weed problems, and establishing strategic management plans and monitoring progress against them.

Achievements of the Australian Pest Animal Strategy include:

- agreement on the need for strategic action and collaboration, and measures to achieve this.
- development of principles that stakeholders reported had informed their own planning and approaches to pest animal management.

The strategies are being revised following an independent evaluation in 2013, with the aim of releasing the new strategies in 2014. Stakeholder consultation will be pivotal to the review process.

Further information

The Sustainability and Biosecurity Policy division works with industry and other stakeholders to promote improved practices for managing agricultural natural resources, encourages sustainable and productive fisheries, improves industry access to safe agricultural and veterinary chemicals and contributes to preparing and responding to biosecurity threats and incursions.

Further information on the Intergovernmental Agreement on Biosecurity (IGAB) is available at: <http://www.daff.gov.au/animal-plant-health/pihc/intergovernmental-agreement-on-biosecurity>

Further information on work on invasive species and biosecurity undertaken by the Department of Agriculture is available at: <http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds>

Victoria's Hawkweed eradication program: an enduring Alpine partnership

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Three species of Hawkweed—Orange (*Hieracium aurantiacum*), Mouse-ear (*H. pilosella*) and King Devil (*H. praealtum*)—have established small populations in the Falls Creek Alpine Resort and surrounding areas of Victoria's Alpine National Park. This is not good news. These places are of national significance due, in part, to their unique flora and fauna. The Hawkweeds' invasive potential threatens the natural values of these areas. Their ability to spread rapidly and disrupt floristic communities is a major concern. In New Zealand, Hawkweeds have already dominated over 500 000 hectares of vegetation and here in Australia early modelling estimated the threat to agriculture at \$74 million annually, in addition to their immediate threat to the unique Alpine National Park.

A Hawkweed Project Control Group oversees eradication programs for all three naturalised species in the Victorian Alps, and comprises representatives from the Department of Environment and Primary Industries, Parks Victoria, Falls Creek Resort Management, and Mt Buller and Mt Stirling Resort Management. Its challenge is to find and kill all Hawkweed plants in the area that is currently at risk of infestation. The terrain is often steep and occasionally dangerous, and even when Hawkweeds are found and treated, any root fragments left behind can regrow. In meeting this challenge, the Group has forged an enduring partnership with researchers that might serve as a model for other invasive species control programs. The partnership has been recognised with a 2013 University of Melbourne Vice-Chancellor's Staff Engagement Excellence Award and a 2014 Parks Victoria Nancy Millis Science in Parks Award. Here we describe the key eradication questions that have been addressed using the Project Control Group's high quality data collection in combination with novel research.

Where are the Hawkweeds?

Given the large potential risk area for Hawkweed infestations, the first research priority was to identify where Hawkweeds are most likely to occur within the landscape. Researchers used local wind data to predict where seeds were likely to have travelled with respect to the presumed source and reproductive satellite populations, initially relying on a single distance observation (Williams et al. 2008) and later expanding to sophisticated simulations of seed travel tailored to Hawkweed seed characteristics and the alpine landscape (Cousens et al. 2012). Researchers



Receiving the University of Melbourne Staff Engagement Award (left to right): Roger Cousens, Nicholas Williams, Cindy Hauser, Neil Smith (DEPI) and Iris Curran (Parks Victoria).

also investigated which habitats would be suitable for Hawkweed germination and establishment, via expert opinion and glasshouse experiments (Bear et al. 2012). Combined into dispersal-constrained habitat suitability maps, these allowed managers to better target their search efforts in the resort and national park.

How hard should we look?

So we know where to look, but how much effort should we put into finding individual plants? Not all ground provides the same search experience for the surveillance teams—steep slopes can slow searchers down, and Hawkweeds are generally easier to spot in grass than when searchers are waist-deep in heath. Researchers developed a model to optimise resource allocation across the landscape, making use of the dispersal-constrained habitat suitability maps and this variable relationship between effort and detection (Hauser & McCarthy 2009). The research team supplies prioritisation maps based on this optimisation method annually to the Project Control Group.

How detectable are Hawkweeds?

While Orange Hawkweeds have distinctive orange flowers, their non-flowering rosettes and the yellow-flowering King Devil and Mouse-ear Hawkweeds can be mistaken for several other daisy species at first glance. Between identification challenges and the varied terrain, there's a risk that search teams might miss Hawkweeds in spite of their efforts and experience.



(left to right) A King Devil Hawkweed mimic. A volunteer seeks hawkweed in the 2012 detection experiment.
Photos: Roger Cousens.

To learn more about the detection rates of ground searches, researchers and agency staff collaborated on two ‘hide and seek’ field experiments (Moore et al. 2011, unpublished data). These revealed enormous variation in the time-to-detect-Hawkweeds depending on the circumstances. Flowering Hawkweeds were often detected quickly but the presence of other yellow-flowered species did cause distraction, and non-flowering rosettes were more often missed than found, especially in dense vegetation types. The resulting detection models can be fed directly into the resource allocation optimisation, and are used by the Project Control Group to pre-emptively set and retrospectively understand the level of confidence they can have in their surveillance data.

The future of Hawkweed eradication

Over the past three seasons the number of new plants found has remained low, despite increased and more strategically targeted surveillance efforts. ‘Eradographs’—which plot the progress of surveillance and control over time—confirm that the Orange and King Devil Hawkweed incursions are tracking well toward achieving eradication (Hester et al. 2011). Mouse-ear Hawkweed was only discovered in 2011 and is still in the early stages of delimitation and control.

As the number of known hawkweed sites has expanded over time, the burden of regularly revisiting sites to ensure effective treatment has come to dominate the program’s budget expenditure. To enhance efficiency, researchers have recently developed statistical models predicting infestation recurrence (Primrose, Hauser & Williams, unpublished data), and are working on optimisations to effectively balance effort spent on revisiting these known sites against effort spent searching for not-yet-discovered sites (Bonneau & Hauser, unpublished data). In parallel, the Project Control Group has trialled new residual

herbicides that are more effective in killing Hawkweeds, albeit with need for increased off-target risk management, thus reducing the need for revisits.

Now that detection experiments have established that human searchers struggle to find non-flowering Hawkweeds, particularly in thick vegetation, the Project Control Group is investigating whether a dog can be trained to detect Hawkweeds as part of the surveillance and monitoring program. With their known heightened sense of smell, agility and ability to be trained, it is possible that a Hawkweed detection dog could more quickly and effectively find plants, whether flowering or not, potentially even sniffing out underground rhizomes that human searchers would never find.

Ridding the Victorian Alps of Hawkweeds is still some years away, but looks to be on track. The Project Control Group has responded swiftly and responsibly to the incursions, investing their resources and harnessing community support to seek out and destroy Hawkweeds across land tenures. They have committed to quality data collection and research support, incorporating new findings back into eradication operations to ensure effective targeting of the Project Control Group’s resources. These Hawkweed invaders are up against a heck of a team!

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Managing invasive plant species using spatially explicit population modelling

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A user-friendly model is under development that simulates the population dynamics of invasive species, their spatial spread over time and allows the incorporation of potential management strategies to examine their effectiveness and cost. The model, named the Spatial Population Abundance Dynamics Engine (SPADE), is a collaboration of the Landscapes and Policy Hub, the Australian Alps Feral Horse Working Group and data providers for relevant case studies.

Though originally designed for modelling animal species, this approach is applicable to a variety of plant species where basic life history information is available and seed dispersal occurs in a predictable, continuous fashion on the modelled scale.

Background

The Landscapes and Policy Hub, funded by the National Environment Research Program, is an interdisciplinary research collaboration that provides guidance for policy makers on planning and management for the conservation of biodiversity at a regional scale. Its work currently focuses on two contrasting landscapes, the Tasmanian Midlands and the Australian Alps, used as case studies. Discussions with land managers of the Australian Alps bioregion identified the potential impact of invasive animal species as an urgent priority for study. To help determine the potential effectiveness and cost of different management strategies to counter the developing issue, we developed a model capable of simulating a species' reproduction, mortality and dispersal throughout the

landscape, as well as potential management strategies to reduce abundance and distribution.

Methods

SPADE is based on a previously published program called STAR (McMahon et al., 2011), developed using Microsoft Excel and Visual Basic to spatially model populations of feral horses, pigs and buffalo in and around Kakadu National Park. Our model has utilised and developed many of the core ideas of STAR to provide greater flexibility and power. SPADE is written in the R programming language and uses the GTK+ toolbox to create a windows-based graphical user interface. The model requires basic population data such as recruitment, mortality and dispersal rates, as well as raster maps of the current and potential distributions of the target species. Its user-friendly interface means that the user can input the required data and quickly and easily run models without specialised training.

An earlier version of SPADE was used in a study on feral deer in Tasmania (in review, *Wildlife Research*). A more extensive article, presenting the modelling methodology and a validation of the model based on detailed historical monitoring data, is currently being prepared for publication in the international journal *Methods in Ecology and Evolution*. The model will be made freely available upon publication, along with a manual and suitable resources. Access to the development version is currently available for selected internal and external collaborators.

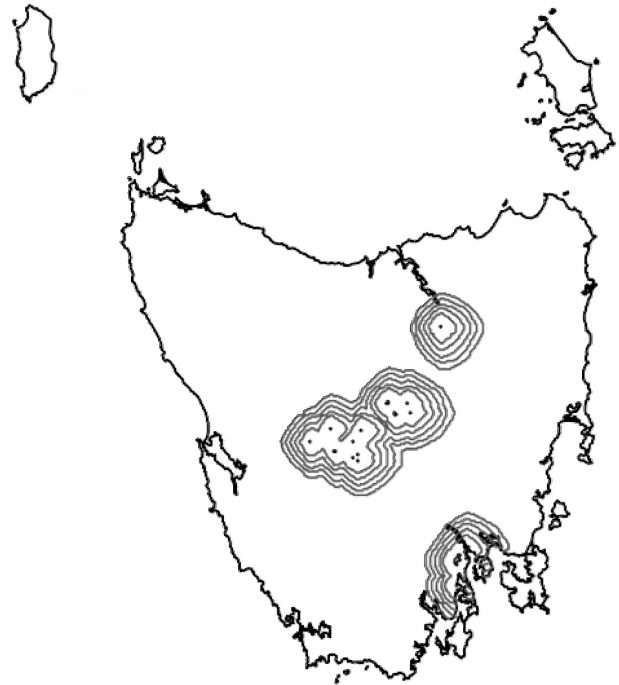
Illustrative model

We present a preliminary model of Orange Hawkweed (*Hieracium aurantiacum*) to illustrate the potential uses of SPADE for modelling invasive plant species. Orange Hawkweed is considered a major threat to biodiversity values in alpine regions of south-eastern Australia, as well as the high country of New Zealand.

We modelled the life cycle of this perennial wind-dispersed member of the daisy family by representing it as four distinct populations—plants, stable seed, dispersing seed and dormant seed. The latter two classes were included based on a review by Williams and Holland (2007) which stated that long distance dispersal and seed dormancy were likely to occur but also to be relatively rare events. We used two different ‘classes’ of seeds, one staying at its parent’s location and the other dispersing randomly, and set their attributes to approximate the seed dispersal model used by Williams et al. (2007) of *H. aurantiacum* on the Bogong High Plains, Victoria. Plant mortality was assumed to be density dependent and in the form given by Lamoureaux (1998; page 21) based on studies of *H. pilosella*. Reproduction was assumed to occur over three months of the year with each plant producing 171 seeds during that time, which in turn germinate and become plants within 10 days (Bear et al. 2012). Dormant seeds were assumed to comprise 1 per cent of the seeds produced. Mortality of growing seedlings was set to give a maximum carrying capacity of 3200 plants per square metre (Lamoureaux, Kelly and Barlow 2003), scaled using species distribution modelling by Beaumont et al. (2009). The number of plants was assumed to be at carrying capacity in square kilometre cells containing observations (obtained from the Tasmanian Government’s Natural Values Atlas) and zero elsewhere. Dispersal between cells in the square grid was assumed to be by wind, which was estimated using summer wind rose data at weather stations across Tasmania and by interpolation between stations elsewhere.

Results

The model forecast the plant population to spread rapidly in the first ten years, increasing its population tenfold and spreading to a vastly larger range. The increase steadies in the successive 40 years, with gains in range determined partly by the prevailing westerly winds. By the end of the 50 year simulation, the population was predicted to be 200 times larger and to cover 14 per cent of the Tasmanian mainland, including part of a World Heritage Area containing globally significant biodiversity. Seasonality has a noticeable effect on the modelled population, with stable and dispersing seeds in particular only present during the breeding season and plant population spiking during this time.



Results of preliminary Orange Hawkweed model, showing central locations of cells with at least 10 plants at start of model run and radiating areas of occupancy every 10 years afterwards up to 50 years.

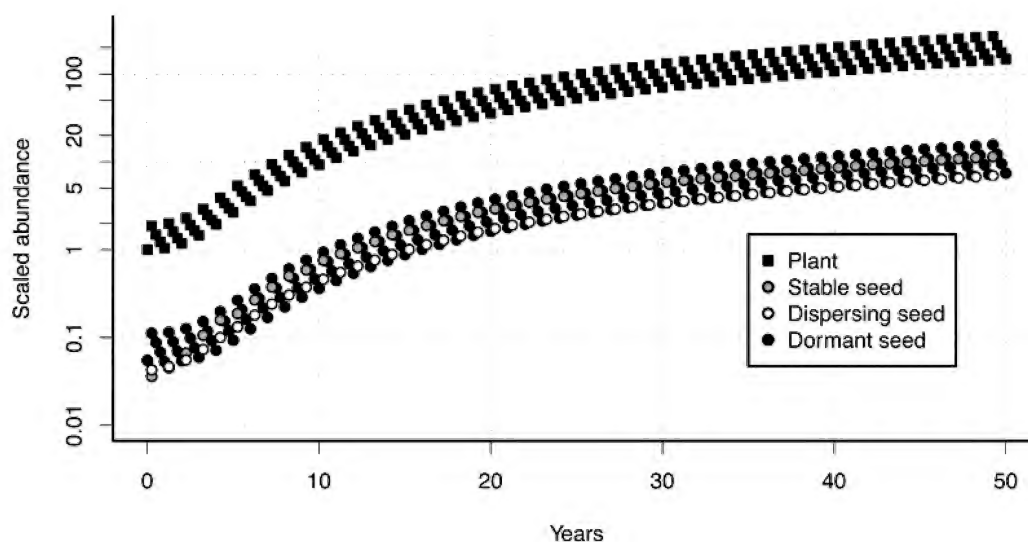
Conclusions

Using basic parameter estimates from the literature, we used the SPADE model to demonstrate a potential ‘worst-case’ scenario for the spread of Orange Hawkweed in Tasmania. The species is considered a ‘sleeping weed’ in that it currently has a limited distribution and abundance, making control or eradication relatively straightforward. This also means that laxity in control at this early stage could have devastating consequences due to the substantial potential for rapid growth and spread. Improved data and alternative management scenarios can be easily added to the SPADE model to compare management strategies, or to fit and ground-truth the model to available data.

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Nick Beeton is an employee of the Landscapes & Policy Research Hub. The hub is supported through funding from the Australian Government’s National Environmental Research Program and hosted by the University of Tasmania.



Change in abundance of Orange Hawkweed over 50 year modelled time period, with all numbers scaled by the initial number of plants in the population.

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Natural Values Atlas (2014). www.naturalvaluesatlas.tas.gov.au, State of Tasmania

Wild Native Rose: untangling the causes of population decline

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Introduction

Wild Native Rose (*Diplolaena andrewsii*) is known from around 600 individuals across only two populations 17 km apart on the Darling Scarp near Perth in south-west Western Australia. A small shrub to one metre with densely stellate hairs on the leaves, it is named for its deep red flowers that are produced through winter and spring. The preferred habitat of Wild Native Rose is Wandoo (*Eucalyptus wandoo*) and Marri (*Corymbia calophylla*) woodlands along hillsides among granite outcrops on brown clay loam. The main population occurs in John Forrest National Park while a smaller population can be found on private property northwest of John Forrest. In February 2010 the species was declared Rare Flora under the Western Australian *Wildlife Conservation Act 1950*.

A major threat to both populations of Wild Native Rose is competition from weeds, particularly Watsonia (*Watsonia meriana*). A South African member of the family Iridaceae, Watsonia invades relatively intact vegetation and forms dense stands on clay loam soils along the Darling Scarp including critical habitat of the Wild Native Rose. Fire appears to facilitate invasion of Watsonia with profuse flowering occurring post fire followed by prolific seed set, bulbil production and seedling recruitment in the years following the burn. A floristic survey of the northern Darling Scarp (Markey 1997) reported Watsonia invasion as one of the most significant threats to intact plant communities and native flora in the region.

In spring 2010, as part of a state natural resource management project addressing recovery actions for critically endangered and rare flora, serious weed invasions and fire history across the populations were mapped. The maps formed the basis of a habitat restoration plan for the species (Bettink 2010). One of the recommendations from that work was to set up trials to look at appropriate techniques for managing *Watsonia* where it was invading critical habitat of Wild Native Rose.

Management trials

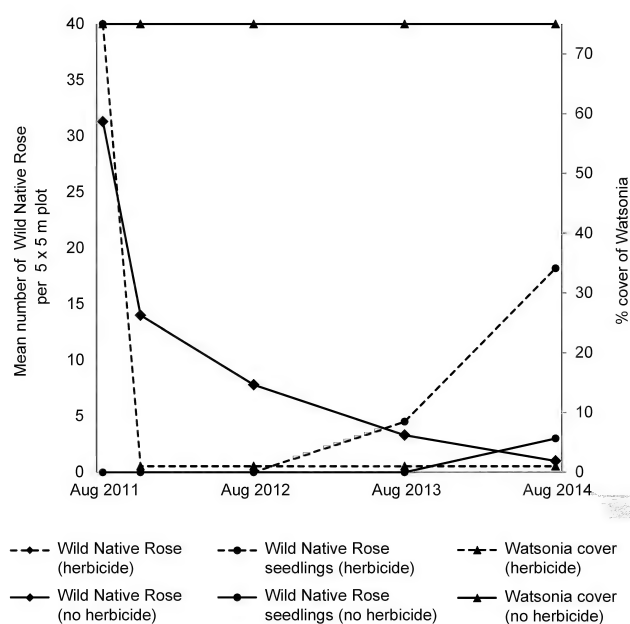
Previous work in Banksia Woodlands and seasonal clay-based wetlands indicated *Watsonia* can be controlled very effectively with the herbicide 2,2-DPA (Dalapon) with little impact on co-occurring native species (Brown & Paczkowska 2013). In August 2011 a series of control and treatment plots were established in John Forrest National Park where a subpopulation of Wild Native Rose occurred among dense infestations of *Watsonia*. Plants of Wild Native Rose were tagged and numbered and *Watsonia* treated with 2-DPA in September just before flowering, on corm exhaustion.



A close-up of a flower and densely-haired leaves of Wild Native Rose, growing in woodland on the Darling Scarp.
Photo: Kate Brown.

Population decline

The 2,2-DPA was very effective at controlling *Watsonia* in the first year of treatment. However over the following three years, across both treatment and controls (no herbicide) there was a dramatic decline in the number of live adult plants of Wild Native Rose. By 2014, the number of live adult plants in control plots had decreased by 97.5 per cent and in the herbicide treatment plots by 96.8 per cent. Given the decline occurred across treatment and controls, it does not appear to be related to the herbicide application. Interestingly there was quite prolific seedling recruitment in 2014. This occurred mainly in the herbicide treatment sites where there was no longer competition from *Watsonia*.



Mean number of Wild Native Rose adults and seedlings and percentage cover of *Watsonia* in 5 m × 5 m treatment and control plots (n=4) over three years. Herbicide was applied (to herbicide' plots) in September each year.

Fire History

As a part of the restoration plan for the species, fire history from 1920 to present was mapped across John Forrest. Like many Rutaceae in south-west Australia, Wild Native Rose does not resprout following fire but appears to persist in the soil seed bank, with prolific germination following fire. What is known about the ecology of Rutaceae in southern Australia indicates that some small shrubs in the family may survive for only 10 years after fire (Auld 2001). For Wild Native Rose little is known about seedling survival post fire, time to first flowering or adult survivorship.

Fire history maps indicate that the sites where our trials were established last burnt 10 years ago. The species was first collected in 1920 and then not again until 1960. Over this time there were few fires in the park. In addition three new subpopulations of the John Forrest population have been discovered in an area burnt four years ago. All this indicates decline across the population at our trial site is possibly linked to time since fire. A number of other factors are also likely to influence plant health and survival, including high densities of *Watsonia*, below average winter rainfall and above average summer temperatures.

Management Implications

To best manage this species and ensure its conservation, we need a greater understanding of the role of fire in the persistence of populations over time. To determine the appropriate fire interval for Wild Native Rose a detailed understanding of time to first flowering, adult survivorship and longevity of the soil seed bank in particular is required. Current knowledge of adult survivorship is based on plants growing among dense *Watsonia* stands and we need to determine adult survivorship in subpopulations where *Watsonia* is absent.

While fire may play a role in persistence of the species over time, fire also facilitates recruitment and persistence of *Watsonia*. Control of *Watsonia* before fire is integral to preventing spread and establishment of the weed and to ensuring successful post fire recruitment of Wild Native Rose.

Although the ecology of Wild Native Rose is poorly understood and the populations are being impacted by some serious threatening processes, the habitat of the species is protected in one of the oldest national parks in Western Australia. By attempting to understand appropriate management for Wild Native Rose and its critical habitat we may also gain a better understanding of appropriate management of fire and weeds across John Forrest National Park.

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Watsonia invading critical habitat at the trial site.
Photo: Kate Brown.

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Volunteers tackle native woody weeds jumping the Garden's fence

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Introduction

The Australian National Botanic Gardens, located on the lower slopes of Black Mountain, Canberra, cultivates only plants that are native to Australia. It adjoins Black Mountain Reserve which contains high quality dry sclerophyll forest and also has special conservation value because of its very high diversity of plant species considered rare in the ACT (Mulvaney 2014). The juxtaposition of the Gardens and Reserve provides the opportunity for native species cultivated in the Gardens to naturalise in its upper bushland sections and potentially invade the Reserve.

The Friends of Black Mountain were aware that sections of the Gardens and its annexes contained infestations of invasive native weeds such as Cootamundra Wattle (*Acacia baileyana*) and Sollya (*Billardiera heterophylla*). These species are widespread in urban Canberra where they have been planted extensively in private gardens and for public landscaping. With the approval of ANBG, the Friends carried out a program of woody weed removal in bushland areas of the Gardens, and the two adjacent annexes, from February 2013 to June 2014 (Purdie 2014).

Weeding outcomes

The Friends and other volunteers carried out the equivalent of 58 person days of weeding over 14 weeding sessions. Forty seven volunteers were involved in the program, averaging about nine per session. Approximately 4200 woody weed plants were removed or cut and poisoned, 87 per cent of which were native species not indigenous to Black Mountain. Fifteen species each had >50 plants removed (i.e. they were abundant taxa), 13 of which were native species.

The woody weed plants removed comprised 115–126 species from 54–58 genera, and included 26–30 exotic species and 89–96 native non-indigenous species. The native woody weed species comprised 31 genera, representing 76–77 per cent of all species and 53–57 per cent of all genera removed. The range of values reported is due to identification uncertainty—it was not possible to match unidentified species removed from different sections of the Gardens during different weeding sessions.

Of the native woody weed species removed, 91 per cent were derived solely from plants cultivated in the Gardens. Species of *Acacia* (35–39) and *Grevillea* (17–20) were removed more often than species from other native genera, i.e. *Acacia* and *Grevillea* were 'more weedy'.



Volunteers removing a dense stand of naturalised *Acacia extensa* plants from a bushland section of the Gardens.
Photo: RW Purdie.

Of the 13 abundant native species, 11 originated solely, and two in part, from plantings within the Gardens. Eight of the most abundant weedy native taxa were species of *Acacia*.

Characteristics of the native woody weed species removed

Most of the native woody weed species removed occur naturally in at least New South Wales and are relatively widespread there. They included 36 of the 43 weeds identified to species level, 9 of the 13 abundant species, and 23 of the 26 weedy *Acacia* species. Of the 13 abundant native species removed, one has wind-dispersed seed and the seeds or fruit of the other 12 species are, or are probably, dispersed by birds or ants. Four of the abundant native woody weed species were relatively long-lived trees or tall shrubs with prolific seed production.

Is ANBG a native invasive weed reservoir?

Just over three times more native weed species than exotic species were removed during the program, and almost seven times more native weed plants taken out than individuals of exotic species. This suggested that native species cultivated in the Gardens can be a potential weed problem, especially the genus *Acacia* which had both the largest number of woody weed species removed and the largest number of abundant species present.

Some woody species cultivated in the Gardens are invasive

Further analysis of the weed data showed that three of the abundant native species, Cootamundra Wattle (*Acacia baileyana*), Green Wattle (*A. decurrens*) and Sollya (*Billardiera heterophylla*), are known to be invasive in the ACT and the former two species widespread there (Berry and Mulvaney 1995). The other 10 abundant native species (Wiry Wattle, *Acacia extensa*; Howitt's Wattle, *A. howittii*; Sydney Golden Wattle, *A. longifolia*; Blackwood, *A. melanoxylon*; Straight Wattle, *A. stricta*; *A. viscidula*; *Dodonaea triangularis*; *Grevillea* aff. *rosmarinifolia*; *Kunzea flavescens*; and Sweet Pittosporum, *Pittosporum undulatum*) also appeared to warrant being treated as potentially invasive in Canberra. All 13 species had been planted multiple times and in many sections of the Gardens, and most of them had invaded bushland areas of the Gardens and annexes that lay adjacent to beds where they had been cultivated. However two species (Sollya, *Billardiera heterophylla* and *Dodonaea triangularis*) had no record of plantings adjacent to bushland areas, and the closest plantings were 100–200 m or more away from their denser infestations.



A pile of *Kunzea flavescens* and *Acacia melanoxylon* plants removed from a cultivated section of the Gardens where they had naturalised. Photo: RW Purdie.

Most woody species cultivated in the Gardens currently are not a cause for concern

Of the native weed species derived solely from plantings in the Gardens, about 68 per cent had only 1–10 plants removed during the program. The small number of plants naturalised suggested that currently these species pose no significant invasive risk.

Because of the apparent weedy potential of species of *Acacia*, all Gardens' planting records for this genus were examined. At least 529 *Acacia* species have been planted

in the Gardens since the 1960s, 7 per cent of which were among weeds removed. The weed data suggested that *Acacia* species with >10 plantings or being planted in 7 or more sections in the Gardens were likely to naturalise, but the number of plantings and number of sections planted in was not a good guide as to whether a species would become invasive. About 72 per cent of all *Acacia* species planted in the Gardens have had 1–10 plantings, i.e. most planted *Acacia* species probably have a low invasive potential.

If the above findings are extrapolated to the rest of the Gardens' plantings, it suggests that although almost 100 woody species (including acacias) have naturalised beyond the planted sections, the majority of cultivated woody taxa probably have a low naturalisation potential and thus currently do not pose a significant invasive risk.

Conclusions

The Gardens currently should not be viewed as a major native woody weed 'problem'. However the small number of naturalised species that have the potential to invade adjacent areas of Black Mountain Reserve warrant management. This should include one or more of the following approaches.

Continuing to retain the natural sections of the Gardens adjacent to the boundary fence as buffer areas in which no new plantings are made and removal of existing cultivated plants is considered.

Implementing an ongoing, regular weed removal program in the buffer and nearby natural areas of the Gardens, targeting both native and exotic weed species.

Making strategic decisions about if and where to retain known weedy native species in cultivated sections of the Gardens, and whether and where to add new plantings of species that might become invasive.

Overall, the weeding program showed that in urban situations, native species can be a bigger weed problem than non-native species and vigilance is required to ensure they are not overlooked. Friends and other volunteer groups can make a valuable contribution to help keep both native and exotic invasive weeds under control.

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When biosecurity is threatened from within: the case of the native environmental weed, *Pittosporum undulatum*

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Sweet Pittosporum (*Pittosporum undulatum*) is a densely foliated shrub or small tree that produces masses of sweet-smelling flowers and large numbers of orange-coloured fruit. As a result, it is one of many Australian native plants that have been favoured in horticulture. Sweet Pittosporum is indigenous to three states, several bioregions, numerous botanical subdivisions, local government areas, and likely several rainforest and wet forest communities. The generally accepted natural distribution of Sweet Pittosporum is rainforest and wet sclerophyll forest of the coast and ranges of southern Queensland, New South Wales, and southeast Victoria. It is now present in South Australia, Western Australia, Tasmania (including King Island), Northern Territory and both Lord Howe and Norfolk Islands. However, within areas in which it is believed to be indigenous, Sweet Pittosporum may become over-abundant and may invade a range of plant communities, posing a significant threat to their biodiversity, integrity, and function.

Sweet Pittosporum has extended its range, spread into drier sclerophyll vegetation to which it is not indigenous, and increased in numbers and density within communities to which it is indigenous. Factors contributing to these outcomes include horticultural plantings (some of which have naturalised), soil nutrient enrichment from urban and rural activities, propagation from fruit in dumped garden waste, and distribution by species including foxes, possums, and both indigenous and introduced birds. 'Spread of *Pittosporum undulatum* in areas outside its natural distribution' is listed as a potentially threatening process in Victoria.

The Pied Currawong is thought to play a major role in seed dispersal of Sweet Pittosporum (Buchanan 1989). Pied Currawong was previously a seasonal migrant, with migration driven in part by availability of fruit and nestlings. Across a portion of its range, Pied Currawong has ceased to migrate and appears to have also increased its range and abundance. This is thought to be due to increased availability of fruit and other foods such as urban scraps. The greater availability of food (both in terms of quantity and availability) throughout the year promotes larger, non-migratory populations of Pied Currawong, which further promote dispersal of seeds of its food plants. Other native birds such as Satin Bowerbird, and introduced species such

as European Blackbird and Red-whiskered Bulbul are also factors in the expansion of Sweet Pittosporum and some non-native weeds.

A further significant factor in the overabundance of Sweet Pittosporum within its natural range is the alteration of fire regimes that inadvertently provides more favourable conditions for it and other invasive plants, including some other native rainforest margin species such as Cheese Tree (*Glochidion ferdinandi*) and Bleeding Heart Tree (*Omalanthus populifolius*). In a similar manner to the fauna interaction described above, a positive feedback loop and cascade effect can occur. Insufficiently frequent and/or intense burning of sclerophyll habitats can allow the spread of mesophyll species, both indigenous and non-indigenous, which in turn reduce the flammability of the habitat. Increasing cover-abundance of Sweet Pittosporum also modifies the floristic composition, structure and some functional elements of invaded communities and ultimately diminishes the biodiversity values of invaded sites. Fire was very likely a major control agent for Sweet Pittosporum before 1750.

In many situations, the use of fire to control weeds, including invasive natives, may not be viable due to a number of factors including the type of vegetation and the fuel load, proximity of infrastructure, cost, and human health (air quality) concerns. The absence of fire, or use of low intensity fires, especially if relatively infrequent, favour Sweet Pittosporum along with several other invasive plants, both native and not.

Road verges and smaller urban and rural bushland remnants are very rarely burnt (if at all), and in many cases they cannot be burnt with sufficient intensity to suppress established populations of mesophyll invaders such as Sweet Pittosporum. Even when core bushland areas are burnt with a regime of sufficient intensity and/or frequency as would normally suppress mesophyll expansion, if those areas are within dispersal range of Sweet Pittosporum infestations, the core bushland may experience heavy reinfestation. Unmanaged infestations act as sources from which reinfestation of managed areas can readily occur.

Harden (2007) noted that Sweet Pittosporum can be an aggressive post-fire coloniser in sclerophyll forest, and can be a troublesome invader in disturbed sclerophyll forests



Left: Sweet Pittosporum is becoming increasingly dominant in the understorey of this Southern Highlands Shale Woodland community, altering community structure and suppressing regeneration of more desirable species.
Right: Sweet Pittosporum invasion of Southern Highlands Shale Woodland threatened ecological community (forest form). As a result of the species being treated as 'native', Sweet Pittosporum has been retained whilst most other invasive species have been removed (right). Photos: Steve Douglas.

in Sydney. Others, including myself, go further and add that sclerophyll communities don't need to be disturbed to be invaded by this species. This situation suggests that when fire cannot be used to effectively control Sweet Pittosporum, other methods may be required. This may extend to taking what might otherwise seem an unreasonable approach of 'zero tolerance' towards this species where it is present outside rainforest and wet sclerophyll vegetation in situations where suitably hot and frequent fires cannot be used.

Recognition of Sweet Pittosporum as a weed outside its natural range is simple. However, determining whether it is a weed is not as straightforward in jurisdictions in which the species is indigenous, even when it is clearly functioning as a weed in many or even most vegetation types in that area. Furthermore, the species is considered indigenous to at least two legally recognised threatened ecological communities in which the issue isn't one of presence but of the degree of actual or potential over-abundance.

In some jurisdictions in which the species is generally accepted as indigenous, it is treated as an invasive species, yet in other such jurisdictions, it may be protected or even favoured. Favour may be solely on the basis that it is regarded as indigenous, and/or because some bush regenerators value it as a "nurse plant", facilitating establishment of other native species, and as a protective buffer on bushland margins. I believe its high degree of invasiveness, allelopathic effects (e.g. Gleadow 1982), and longevity make Sweet Pittosporum unsuitable for consideration as a low-risk "nurse plant".

I suggest that consideration be given to wider legislative declaration of Sweet Pittosporum as a "noxious" species such that it can no longer be sold or traded, whether it is accepted as indigenous to that jurisdiction or not. Whilst some bush regenerators and land managers hesitate on the question of whether to retain the species in some sites, I recommend a version of the precautionary principle, based on the species being highly invasive and over-abundant, leading to a reduction in biodiversity: 'if in doubt, take it out', though carefully. However, labelling this species as a weed has led to it sometimes being rather aggressively removed, including from threatened communities in which it is believed to be indigenous. This can be detrimental for the habitat, and may extend to complete habitat loss and/or the replacement of Sweet Pittosporum with non-indigenous weeds that take advantage of severe disturbance. Discretion is clearly required.

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A full bibliography and unabridged version of this article can be obtained by contacting the author.

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Dr Jekyll and Mr Hyde: recently introduced pests of invasive flora may also threaten endangered native species

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Summary

In the last 12 months two pest species were accidentally introduced to Greater Sydney. Both pests are likely to impact native as well as exotic species, raising interesting questions on biosecurity and the management of accidental biocontrol.

Tomato Red Spider Mite

Tomato Red Spider Mite (*Tetranychus evansi*) is small sap-sucking mite generally found on plants in the Solanaceae family. It was first detected in Australia on the herbaceous weed *Solanum nigrum* at Port Botany by the then Australian Government Department of Agriculture, Fisheries and Forestry Operational Science Program in August 2013 and subsequently at Rosebery, Sydney Airport, Rockdale, Darlington, Alexandria, Kurnell, Homebush and Merrylands (Biosecurity SA 2013) and independently at Lane Cove (Kearney & Kearney 2014).

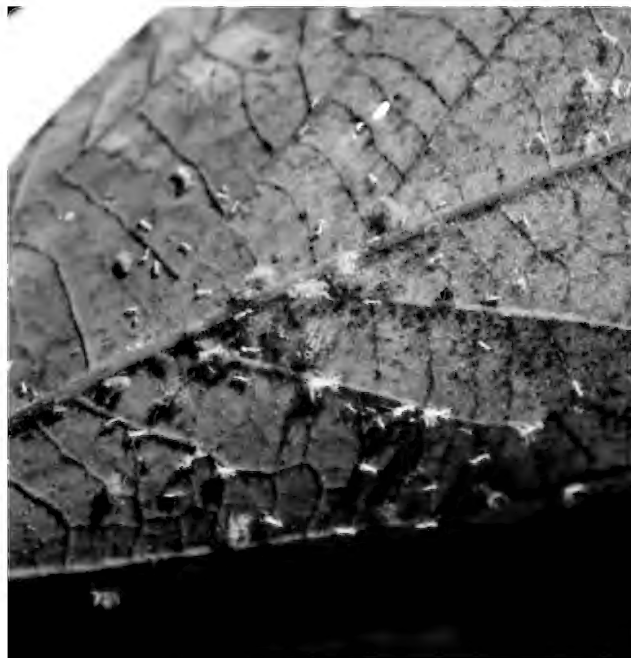
Tomato Red Spider Mite is superficially similar to a number of other species including the widely established exotic two-spotted spider mite (*Tetranychus telarius* sp. agg.). Microscopic identification is recommended for which a key is available online (Seeman & Beard 2005). The mite has been recorded overseas on numerous *Solanum* species including the exotic plant pest Blackberry Nightshade (*Solanum nigrum*), as well as other plant pests including Couch (*Cynodon dactylon*), Lantana (*Lantana camara*) and Castor Oil Plant (*Ricinus communis*).

In Australia the species has been recorded on exotic Glossy Nightshade (*Solanum americanum*; Kearney & Kearney 2014), exotic Blackberry Nightshade (*Solanum nigrum*; Biosecurity SA 2013) and native Kangaroo Apple (*Solanum aviculare*; Kearney & Kearney 2014, Ridgeway *pers. obs.*). Other potential native hosts include *Solanum* spp., orchids, and *Galium* spp. (Migeon & Dorkeld 2013).

At Lane Cove, scattered individuals of Tomato Red Spider Mite rapidly progress to dense orange infestations comprising thousands of individuals with visible webbing. Mites are mobile and have been observed to disperse by wind, native fauna and on clothing. One population of native Kangaroo Apple reported by Kearney & Kearney (2014) in January this year had experienced 50 per cent

mortality when revisited in August, with all plants exhibiting some level of mite damage (Ridgeway *pers. obs.*). The mite has similarly impacted the environmental weed Glossy Nightshade at this site. The full impact of the recently arrived mite on native and exotic flora is yet to be seen.

There is serious potential for this mite to impact two threatened *Solanum* spp., endangered under NSW law, in the Greater Sydney region. The shrub *Solanum armourense* is restricted to a small number of individuals in four colonies between Mt Armour and Wombeyan in the southern Blue Mountains. The shrub *Solanum celatum* is similarly restricted to a small number of individuals between Wollongong, Nowra and Bungonia south of Sydney. Given the extremely low population sizes of these endangered species, the potential impact of Tomato Red Spider Mite is of concern.



Tomato Red Spider Mite on native Kangaroo Apple (*Solanum aviculare*). Photo: Peter Ridgeway.

Asian Woolly Hackberry Aphid

The Asian Woolly Hackberry Aphid (*Shivaphis celti*) was first detected in Australia in September 2013 on blackberry plants from China, and subsequently in the wild at Mascot and Camperdown. A national meeting of the Consultative Committee on Emergency Plant Pests determined that the pest was not an emergency plant pest and that therefore no further action would occur. The species is a known parasite on *Celtis* species.



Asian Woolly Hackberry Aphid (*Shivaphis celti*) on Chinese *Celtis* (*Celtis sinensis*). Photo: Alex Burgess-Buxton.

Chinese *Celtis* (*Celtis sinensis*) is an exotic tree and declared Class 4 weed (under the NSW *Noxious Weeds Act 1993*) in most of the Hawkesbury-Nepean region. In Greater Sydney the species is semi-deciduous from mid- to late-winter to Spring. In March 2014 the Asian Woolly Hackberry Aphid was observed to be significantly impacting Chinese *Celtis* along the Hawkesbury-Nepean River and its tributaries between Richmond and Camden and along the Parramatta River (Burgess-Buxton *pers. obs.*). Aphids caused complete defoliation of immature Chinese *Celtis* up to about 1.5 m height, and significant defoliation to mature specimens. This impact has in some cases been confused with annual deciduous activity. It is not yet clear how effective this pest will be as an accidental biocontrol of this invasive plant.

In the Greater Sydney region the Native *Celtis* (*Celtis paniculata*) is present in coastal suburbs and in some patches of Western Sydney Dry Rainforest. There is cause for concern that the Asian Woolly Hackberry Aphid may have detrimental impact on this species. Greater awareness of this selective pest by the conservation and bush regeneration community would be merited.

Recommendations

Both the Tomato Red Spider Mite and the Asian Woolly Hackberry Aphid are already established in the wild and may be difficult or impossible to contain given their modes of dispersal. Nonetheless there is clearly merit in further dissemination of advice to conservation land managers regarding these species and their potential impacts. An article is currently under preparation for the newsletter of the Australian Association of Bush Regenerators to this purpose.

The NSW Wildlife Atlas (*BioNET*) maintained by the NSW Office of Environment and Heritage has not registered these species. Registration would encourage submission of records and assist in tracking distribution and establishment of these pests over time.

Immediate concern should be targeted to the potential impact of Tomato Red Spider Mite on endangered *Solanum* species in the Greater Sydney region. Field operators in the southern Greater Blue Mountains World Heritage Area should be informed of the species and encouraged to report potential outbreaks to the NSW Department of Primary Industries. Development of a fact sheet would assist with this purpose. Travel between infected areas and identified high risk sites should be avoided. Field staff should be encouraged to look out for isolated individuals before dense masses develop. There are presently no chemicals registered for control of either pest on native flora, however Tomato Red Spider Mite can be effectively contained by burial under black plastic.

The threat of Tomato Red Spider Mite should be identified as a threat in recovery planning for *Solanum armourense* and *Solanum celatum*. Both species are considered data deficient and research programs should address this new threat and potential management responses as a priority.

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Considerations for large-scale biodiversity reforestation plantings.

Part 1: securing access to land

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Introduction

This is the first in a series of articles that will discuss learnings from the implementation of large-scale biodiversity-focused reforestation plantings. The articles will provide insight into the evolution of environmental plantings of modern times in the context of programs ranging in scale from catchments to continent-wide.

Environmental plantings, tree planting projects, forest restoration and bush regeneration have been undertaken in Australia since the 1960s. Often these projects have been initiated and implemented at the local scale targeting specific restoration outcomes such as improving structure, function and species composition of a degraded local creek by a community or Landcare group. Social, ecological and educational outcomes have benefited the community and broader environment with increased public connection to the environment at the regional level.

In 1982 with increasing concerns about land clearing and degradation, the Australian Government established

the National Tree Program and in 1989 committed to an ambitious billion tree planting project that achieved 700 million trees planted before the program was ended after the 1996 election.

Recently, there has been an increase in reforestation projects at the landscape scale both in Australia and abroad for varying reasons. There is a diversity of drivers, mechanisms, policies and legislation for large scale reforestation plantings which differ from small-scale plantings. Some examples of these drivers and more significant project examples include:

- The Carbon Farming Initiative (CFI) introduced by the Australian Government in 2011. Under this program, landowners can generate voluntary carbon credits via an approved reforestation methodology. Despite the recent repeal of the carbon pricing mechanism, the CFI remains and provides an incentive for landowners to undertake large-scale plantings.



Large scale reforestation requires an "industrial" approach. Photo: Dan Cole.

- Environmental offsets, which are now more prolific in Australia, including native vegetation and koala offsets schemes. These are mostly regulated by state governments in response to land clearing. The private sector, particularly residential development companies, has undertaken large-scale tree planting projects to meet offset requirements or as developer contributions for the approvals process.
- The Great Eastern Ranges Initiative which assists in the management and restoration of a 3600 km conservation corridor from the Victorian Alps to the Atherton Tablelands in far north Queensland. The initiative is delivered through strategic partnerships between governments, Indigenous groups, landholders, industry, non-government organisations and community groups.
- Australian Government funding programs to increase forest cover on a large scale, protect hydrological cycles and improve coastal marine ecosystems, for example Caring for our Country, Green Army, 20 Million Trees.
- Local government projects such as Brisbane City Council's 2 Million Trees project which covered approximately 500 hectares, on more than 100 sites between 2007 and 2012.
- The Million Trees Program which the South Australian Government is undertaking in Adelaide and surrounds.
- The Gondwana Link project in south-western Australia which has been operating for over a decade to restore connectivity to 1000 km of bush.
- Farmers are increasingly planting large areas back to trees with benefits to their agricultural management such as windbreaks, remediation of degraded creeks and drainage lines and with conservation and habitat objectives.

The large-scale reforestation projects listed above have identified considerations and constraints that need to be negotiated to ensure success at this scale. In this issue, we focus on land tenure or land provision. In future issues, we will explore other considerations and challenges for successful large-scale reforestation, including:

- planning
- implementation
- maintenance
- governance and project management
- landholder and community engagement
- risk management and contingency planning
- project monitoring and evaluation.

Land tenure and securing access to land

Land tenure/land provision is often the first of many potential barriers that may be encountered in developing a large-scale reforestation project. Successfully securing access to land on which the project may be conducted is

a critical component to ensuring a large-scale biodiversity reforestation planting can be successfully undertaken.

Large-scale projects will often have multiple landowners, authorities, stakeholders and community interests. Accessing land and the associated land tenure requirements can vary significantly. For public institutions such as local councils, partnerships with other public institutions are common, the current land use can be the primary driver for locating environmental plantings.

For the private sector or for any public institution delivering vegetation offset requirements or carbon credits (administered by the Clean Energy Regulator), securing land tenure is often required due to the level of certainty required under such arrangements. Either the land needs to be owned by the organisation delivering the project or an agreement is required with the landowner for the organisation to deliver the project. Otherwise a new location needs to be found where tenure can be appropriately secured. It is also important to understand that securing access to land, particularly securing land tenure can have a long lead time.

The Brisbane City Council (BCC) 2 Million Trees (2MT) project utilised land owned or managed by BCC, private landowners, infrastructure providers, and state and federal government agencies. SEQ Water (the South East Queensland Bulk Water Supply Authority) provided multiple sites whereby cleared areas surrounded by remnant forest were reforested. Successful negotiations were also achieved with Queensland Correctional Services to plant 400,000 tree and shrubs on more than 80 hectares as bio-diverse corridor plantings. The 2MT project was started before suitable lands had been secured and considerable negotiations had to take place in a short period of time to meet project time goals.

Land use agreements: forest permanence and land use restrictions

Government-regulated offset or carbon credit plantings are required to exist in perpetuity will often look for third parties to provide access to land under various agreements. This can be an opportunity for landowners interested in revegetating their property, whereby the proponent seeking access to the land may cover the associated costs, and or long term leasing arrangements (for carbon credits).

Such agreements between the landholder and proponent may require a covenant on title. Similarly there may be site specific items that impact on the landholder. It's at this stage, particularly with private landholders, that there may be some developmental concern on progressing agreements. There is always the possibility that once a landholder understands the conditions of such agreements, such as forest permanence or that certain land use activities such as harvesting timber may be ineligible that land may not be provided. The time required to organise land provision can also incur expenses, particularly if negotiations fail and need to start again with another landholder.



Large scale planting adjoining Logan River in QLD. Photo: Dan Cole.

Under the 2MT project, private landowners were offered free reforestation subject to varying conditions of size, appropriateness and permanence of the forest being registered on state land title (i.e. a covenant). Due to permanence requirements, a great deal of negotiation and effort was expended by all parties (BCC, contractors and landowners) to agree on the outcome before on-ground works could commence. As a result of the perceived covenant restrictions, only four private properties participated in the 2MT project, from around 50 that contained suitably sized areas for planting.

Community and stakeholder engagement

It is important for any large-scale reforestation project that the community and particularly adjoining landholders are informed early in such projects. Landholders in rural and peri-urban landscapes can have contrasting views on land use and particularly the use of public funds. Engaging with the community early in the site identification and project development stage is critical to ensuring local understanding, abating conflict, gaining potential support and identifying site-specific risks that will inform the planning phase.

Preliminary site assessment

Preliminary site assessments need to consider historical land use. Some identified sites will have great potential to reinstate large scale native forests. Other sites may be degraded from past activities such as grazing that can predispose reforestation efforts to failure. These and other risks will be discussed in a future article in this series.

Concluding summary

Large-scale biodiversity reforestation is increasing. Securing control over suitable lands is essential to the success of any planting project, but may involve a great deal of negotiation. In the next issue we will examine site planning, planting methodologies and plant procurement.



Community planting days assist in gaining support for large projects. Photo: Dan Cole.

ANPC member profile

Kate Brown

Workplace: Western Australian Department of Parks and Wildlife, Swan Region WA (based in Perth)

Role: Ecologist



Kate Brown surveying weeds on Carnac Island, off Perth WA, in October last year. Photo: Jon Dodd.

What projects are you working on at the moment?

My work involves the restoration and protection of regionally significant bushlands on the Swan Coastal Plain and in the Perth Hills. South-western Australia is renowned for its floristic diversity and high level of endemism. Unfortunately the Swan Coastal Plain has been heavily impacted upon by urban development and remnant bushlands in the region are subject to a range of threatening processes including invasion by introduced plant species. Understanding how to manage some of the more serious weeds, including South African perennial grasses and geophytes where they are invading native plant communities, is a major focus of my work.

One of the projects I am working on at the moment is looking at the role of prescribed fire in weed invasion in Banksia/Tuart (*Eucalyptus gomphocephala*) woodland. The Banksia/Eucalypt woodlands on deep quaternary sands are the dominant vegetation of the Swan Coastal Plain. Originally covering around 280 000 ha, more than half have been cleared for urban development. Paganoni Swamp Reserve, a Banksia/Tuart woodland on the southern Swan Coastal plain, is one of the largest and most intact of these remnants. It had been unburnt for more than 30 years when a prescribed burn to part of the reserve was undertaken by the Western Australian Department of Parks

and Wildlife in Autumn 2011. For the last three years following the prescribed burn we have been examining the susceptibility of the woodlands there to weed invasion post fire. This has included examining the role of kangaroo grazing in the establishment of serious weeds. What we are finding is that, in the short term at least, prescribed Autumn fire can increase weed abundance in these woodlands. We are also finding that kangaroo grazing is preventing some of the more serious weeds like Perennial Veldt Grass (*Ehrharta calycina*) from establishing in the reserve and this has important implications for remnant Banksia/Tuart woodland where native herbivores are no longer a part of the system.

I have also been working for a number of years on invasive South African geophytes, trying to understand how they spread and establish in undisturbed plant communities as well as how to control the most serious species. Geophytes are plants that die back to underground storage organs, bulbs corms, tubers or rhizomes, over our long hot summers. It is a strategy employed by plants of Mediterranean ecosystems across the world to avoid drought and fire, and to cope with low nutrient soils. Some of most serious invasive species include Freesia (*Freesia alba* x *leichtlinii*), Sparaxis (*Sparaxis bulbifera*), Watsonia (*Watsonia meriana*), Yellow Soldier (*Lachenalia reflexa*), One Leaf Cape Tulip (*Moraea flaccida*) and Black Flag (*Ferraria crispa*). For species such as Watsonia, and Cape Tulip, fire appears to play a role in establishment and spread of populations with prolific flowering, seed set, and seed germination in the seasons following fire. The good news is we have found a number of herbicides that offer highly selective and effective control for these species where they are invading intact vegetation. We have also found that for species such as Freesia and Yellow Soldier, seed is very short lived (less than 2 years) in the soil seed bank. So if populations are selectively controlled for two years before a burn, fire can help restore cover of native vegetation, stimulating germination and establishment of native flora in the absence of competition from these weeds.

Over the last two spring seasons, I have been working with colleagues to relocate and rescore floristic quadrats that were established 20 years ago as part of a regional flora survey in the seasonal clay based wetlands, a threatened ecological community, of which over 90 per cent has been cleared on the Swan Coastal Plain. These wetlands fill with winter rains and are characterised by temporally overlapping suites of annual and perennial herbs that flower and set seed as the wetlands dry through spring.

They comprise a flora of over 600 species, of which at least 50 per cent are annual or perennial herbs. 16 species occur only on the clay-pans and many are rare or restricted. We are hoping to gain an understanding of how floristic composition of these wetlands has changed over the last twenty years and what the management implications might be.

How long have you been a member of ANPC?

I have been an ANPC member for about five years. I joined because of the range of practitioners and scientists involved in the organisation and the focus on real outcomes for plant conservation. In October 2013 I was elected as a member of the ANPC Management Committee where I hope to become more involved in the network and help support the work that ANPC does.

How did you end up working in plant conservation? (what/who inspired you?)

I started out as a horticulturalist and ended up working as a gardener in the Botany School at Melbourne University in the early 1980s. Just about everybody there inspired me to become involved in plant conservation! I was encouraged to become involved in collecting specimens for lodgement in The University of Melbourne Herbarium and to enrol in a couple of second year botany units including plant taxonomy and ecology. I was also spending a lot of time bushwalking in the Victorian alpine country, learning the flora and as well as the issues around plant conservation. One summer, on a bushwalking trip to Tasmania I ended up on a botany course run by the University of Tasmania, out of Mt Field National Park.

In the early 1990s I moved to WA and finally undertook my science degree and was offered a job working for a non-government organisation, the Environmental Weeds Action Network, where I worked with land managers and community groups to establish case studies demonstrating best practice weed management at a series of regionally significant bushlands across the Swan Coastal Plain. The case studies were eventually written up and published in a book (Brown and Brooks 2002). When I moved across to Parks and Wildlife in 2003 I was able to keep working on environmental weeds. This included continually updating management information originally published in Brown and Brooks (2002). This is currently available on the Department of Parks and Wildlife *Florabase* website (Brown and Bettink 2009). I guess what continues to keeps me inspired is our remarkable flora and the botanists, plant ecologists and community volunteers I am fortunate enough to work alongside.

Are you involved in any conservation activities in your spare time?

Over the years I have worked with a number of volunteer groups, including the Friends of Shenton Bushland, and the Friends of Brixton Street Wetlands. Shenton Bushland is my local patch of *Banksia* woodland. The Friends group were instrumental in protecting the bushland from development 25 years ago and have done a wonderful job managing it ever since.

When I first moved to WA I joined the Western Australian Wildflower Society and became an active participant in their flora survey program. The program takes volunteers out to survey and document the flora and vegetation of significant bushlands across the south west. It was how I first got a handle on WA's amazing flora. I also occasionally volunteer for Parks and Wildlife botanical survey work and that takes me away from the Swan Coastal Plain and into some of the more remote deserts of WA.

Further reading

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Report from New Zealand Plant Conservation Network

Alex Fergus

Email: afergus@doc.govt.nz; NZPCN website: www.nzpcn.org.nz

New Zealand Moss Flora project significantly advances

Dr Allan Fife has published new treatments for six moss families, the Amblystegiaceae, Buxbaumiaceae, Encalyptaceae, Entodontaceae, Ephemeraceae, and Erpodiaceae. The decision was made by himself and his colleagues at the Allan Herbarium at Landcare Research to progressively publish individual family treatments as part of the eFlora (New Zealand's dynamic, continually updated, electronically-based Flora). The six 'fascicles' recently published can be seen as effective means to move the Moss Flora project toward completion.

Access to these six new moss family treatments are currently available from the eFlora in one of two ways, by searching for a name online with the eFlora (<http://www.nzflora.info/index.html>) or downloading the new taxonomic treatments as fascicles in PDF format (<http://www.nzflora.info/publications.html>).

For further information on the eFlora please contact the project Editor-in-Chief Dr Ilse Breitwieser (breitwieseri@landcareresearch.co.nz) or Allan Herbarium research leader Dr Peter Heenan (heenanp@landcareresearch.co.nz), and for information on the moss treatments contact Dr Allan Fife (fifea@landcareresearch.co.nz).

Seed dispersal information available on NZPCN species fact sheets

The seed dispersal mechanisms for over 2000 New Zealand species of vascular native plants are being added to NZPCN species fact sheets. This information has been generously supplied by Mike Thorsen who, along with Kath Dickinson and Phil Seddon, published 'Seed dispersal systems in the New Zealand flora' in *Perspectives in Plant Ecology, Evolution and Systematics* in 2009.

The various methods by which the New Zealand flora disperse their seeds are as varied and interesting as ballistic propulsion, and understanding these mechanisms has multiple applications such as its crucial relevance for managing *in situ* populations of Threatened or At Risk species.

A classification of New Zealand's terrestrial ecosystems

The New Zealand Department of Conservation's Nicholas Singers and Geoff Rogers have published a classification of New Zealand's terrestrial ecosystems. This long-awaited classification system is based on the relationships between the abiotic environment and its biotic overlay. As Singers and Rogers describe, the 'need to classify New Zealand's diverse and complex ecosystems is driven not only by scientific curiosity, but also by increased land use planning activity'. This resource provides a comprehensive list of ecosystem units with information on their distribution. The full document is available to download: (<http://www.doc.govt.nz/documents/science-and-technical/sfc325entire.pdf>)

Two interactive keys updated

Murray Dawson of Landcare Research has updated the interactive key to Native New Zealand Orchids (www.landcareresearch.co.nz/resources/identification/plants/native-orchid-key) by incorporating extensive additional character scores, particularly for fruiting material; the links to orchid profiles on the NZPCN website have also been repaired. Murray has also added 86 new species to the New Zealand Weeds Key (www.landcareresearch.co.nz/resources/identification/plants/weeds-key), as well as a set of habitat characters (e.g. grasslands, parks, gardens and footpaths; roadsides and disturbed sites) for all weeds within the key. There are now more than 600 taxa in the key. Murray can be contacted for further details (DawsonM@landcareresearch.co.nz).

A new interactive key to *Cotoneaster* species in New Zealand

David Glenny of Landcare Research has produced an interactive key to *Cotoneaster*, an ornamental shrub genus common in New Zealand gardens, but also present in the wild in the form of a number of species are troublesome weeds. The key uses features from leaves, flowers, and fruit to make identification through most months of the year possible. The key is available here (www.landcareresearch.co.nz/resources/identification/plants/cotoneaster-key) or David can be contacted for further details (GlennyD@landcareresearch.co.nz).

Visit www.nzpcn.org.nz for more information and updates from the network.

Conference report

Australian Network for Ecology and Transportation Conference

Review by Martin Driver. Email projects@anpc.asn.au

The inaugural conference for the Australian Network for Ecology and Transportation (ANET) was held recently at Coffs Harbour from July 20 to 23, 2014. The conference had over 140 registered participants from 8 countries, with 50 presentations and 17 poster displays and a field trip on the final day. The main thrust of the conference was in sharing information and learning about the many impacts of roads, railways and other linear utility infrastructures on natural ecologies and the methods devised in mitigating these impacts. The conference presentations emphasised that roads and other linear infrastructure was 'where human society meets nature', and that as the demands of built infrastructure extend further throughout the world it is increasingly important to mitigate the negative effects of these corridors on the natural ecology.

ANET brought together a breadth of disciplines, though this first conference was heavily weighted towards mitigating fauna mortality through engineering solutions.

There were however some flora and vegetation habitat management related papers and an secondary focus on avoidance/minimisation impacts to flora and habitat and subsequent mitigation of impacts through rehabilitation and management. The need for resourcing for seed supply systems and ongoing targeted monitoring of actions to ensure success was a universal theme.

The field trip to the Roads and Maritime Services' Pacific Highway reconstruction works was a hands-on highlight for most participants. This is the single longest roads infrastructure project currently underway in Australia and the visit demonstrated some of the habitat and flora issues of construction including listed Endangered Ecological Communities, significant habitats, plant communities and cultural/heritage areas and associated protection, rehabilitation and enhancement works.

This first national ANET conference brought a multidisciplinary approach to the very important and complex issues of potential conflict in linear infrastructure design, construction and operation. The overarching message of the conference was 'the future is not somewhere we are going, but something we are making'. For more information on ANET, visit: www.ecoltrans.net.

Upcoming conferences and workshops

10th Australasian Plant Conservation Conference

*11–14 November 2014
Hobart, Tasmania*

The 10th Australasian Plant Conservation Conference (APCC10), hosted by the Australian Network for Plant Conservation and the Royal Tasmanian Botanic Gardens, is shaping up to be an exciting event with many fascinating speakers, practical demonstrations, tours and fields trips. The APCC10 overall theme is "Sustaining Plant Diversity—Adapting to a Changing World". Sub-themes include: securing biodiversity, partnerships for biodiversity, prioritising actions, animals in plant conservation and engagement and communication in the modern world. For more information visit <http://www.anpc.asn.au/conferences/2014/>

IUCN World Parks Congress

*12–19 November 2014
Sydney, New South Wales*

The IUCN World Parks Congress 2014 is a landmark global forum on protected areas. The Congress will share knowledge and innovation, setting the agenda for protected

areas conservation for the decade to come. Building on the theme "Parks, people, planet: inspiring solutions", it will present, discuss and create original approaches for conservation and development, helping to address the gap in the conservation and sustainable development agenda. For more information visit <http://www.worldparkscongress.org/>

Society for Ecological Restoration Australasia (SERA) 2014 conference

*17–21 November 2014
New Caledonia*

Society for Ecological Restoration Australasia (SERA) meetings aim to provide an essential international forum for scientists and practitioners who look to restoration as a means to conserve the planet's dwindling biodiversity and failing ecosystems. These meetings provide a critical platform to assist us in defining the principles of restoration, understanding goals and milestones, debating what ecosystem functions to measure and closing the gap between the science of restoration ecology and the practice of ecological restoration. For more information visit: <http://www.seraustralasia.com/pages/conference.html>

Information resources and useful websites

Release of the 2014 Australian Government threat abatement plan for *Phytophthora cinnamomi*

Alex Blanden

Environmental Biosecurity Section, Department of the Environment.

Email: invasivespecies@environment.gov.au

The *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi* came into effect on 31 January 2014 to address the key threatening process 'dieback caused by the root-rot fungus *Phytophthora cinnamomi*', which is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Threat abatement plans provide a framework for guiding and prioritising activities across government agencies and organisations. They reflect the latest scientific research and best practice management techniques. Threat abatement plans are reviewed at 5 yearly intervals to ensure they remain effective and efficient in managing the threat posed by a key threatening process to Australia's environment.

Consultation process and drafting

The threat abatement plan was developed by the Department of the Environment in close consultation with state and territory land managers and leading researchers. This process included a meeting of experts in March 2012 at the Australian National Botanic Gardens in Canberra, as well as a 3 month public consultation process during 2013. Thanks to the contributions of many people, the 2014 plan reflects the advancements that have been made in our knowledge and understanding of *P. cinnamomi* and its impacts upon native flora and fauna.

Some of these advancements include improvements in detection techniques using polymerase chain reaction (PCR), which enables more accurate and cost-effective detection of *P. cinnamomi* in infested soil; the discovery of at least 32 species of *Phytophthora* (other than *P. cinnamomi*) in various parts of Australia including *P. cryptogea*, *P. megasperma*, *P. multivora* and *P. arenaria*, which are also known to cause significant damage in the wild to a variety of different plant species; and developments in mapping technology which have allowed more accurate monitoring of the distribution of this pathogen and its impacts.

Aims and objectives of the threat abatement plan

The goal of the threat abatement plan is to identify and protect environmental assets, such as threatened species and ecological communities listed under the EPBC Act and other matters of national environmental significance, from the impacts of *P. cinnamomi*.

The plan includes:

- strategies to prevent *P. cinnamomi* spreading into areas that are free of disease;
- strategies to reduce the impacts in infested areas;
- recovery actions for the conservation of biodiversity assets currently being affected.

In addition to these broader aims, the objectives within the threat abatement plan are to:

- Identify and prioritise for protection both biodiversity assets and areas where there is potential for *P. cinnamomi* to cause native species or ecological communities to become eligible for listing under the EPBC Act.
- Reduce the spread of *P. cinnamomi* to, and reduce its impacts on identified priority biodiversity assets, such as world heritage areas, or areas where there is potential for *P. cinnamomi* to cause native species or ecological communities to become eligible for listing under the EPBC Act.
- Encourage communication of knowledge about *P. cinnamomi* and its impacts on biodiversity, and the actions suggested in the plan to combat these impacts.

The threat abatement plan and its associated background document can be viewed at: <http://www.environment.gov.au/resource/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi>

For more information on this threat abatement plan, or on *Phytophthora cinnamomi* please contact the Environmental Biosecurity Section in the Department of the Environment by emailing invasivespecies@environment.gov.au

Information resources and useful websites (cont.)

New international code on invasive alien species for botanic gardens

Following the publication of the *European Code of Conduct for Botanic Gardens on Invasive Alien Species* (<http://www.botanicgardens.eu/downloads/Heywood&Sharrock-2013.pdf>), International Association of Botanic Gardens (IABG), Botanic Gardens Conservation International (BGCI) and International Union for Conservation of Nature (IUCN / Invasive Species Specialist Group (ISSG) have agreed to form an informal international working group to consider the preparation of a Global Code for use by all botanic gardens and arboreta.

Botanic Gardens Australia and New Zealand (BGANZ) are forming a working group, representing the botanic garden community in Australia, New Zealand and the south Pacific.

The remit of the informal working group will be:

- to review the European Code and propose how it could be adapted to meet the situation in different parts of the world;
- draw on the wealth of experience available from those gardens and arboreta that have successful IAS programmes, both successes and failures;
- assemble all the relevant documents (codes, action plans, etc.);
- harmonize the information and prepare a draft global code;
- make proposals for international review;
- make proposals for promotion, implementation, follow-up and monitoring of the code;
- draw up a timetable of actions.

If you are interested in participating in the discussion, please contact Dale Arvidsson – President Botanic Gardens Australia and New Zealand at president@bganz.org.au.

Dark Emu: Black seeds: Agriculture or Accident?

Author: Bruce Pascoe

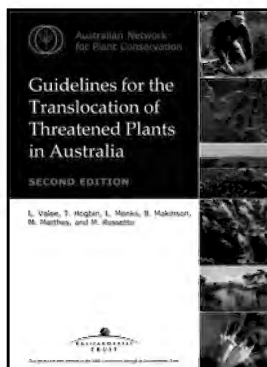
Publisher: Magabala Books, 2014

Paperback ISBN: 9781922142436

(176 pages with photographs and maps)

Bruce Pascoe's *Dark Emu* argues for a reconsideration of the hunter-gatherer tag for precolonial Indigenous Australians. The book builds the case that Indigenous people right across the continent were using domesticated plants, sowing, harvesting, irrigating and storing—behaviours inconsistent with the hunter-gatherer tag.

While this argument has been put forward by other recent publications, Pascoe extends it to challenge the hunter-gatherer tag as a convenient lie. Almost all the evidence cited by Pascoe in support of his argument is from diaries and other records of early explorers of Australia. The book compiles records, photos and maps of documented native Australian plant cultivation, use and storage in the early European exploration and settlement phase of the country.



Guidelines for the Translocation of Threatened Plants in Australia

The deliberate transfer of plants or regenerative plant material from one place to another (eg re-introduction, introduction, re-stocking).

Second Edition 2004 | L. Vallee, T. Hogbin, L. Monks, B. Makinson, M. Matthes and M. Rossetto
Australian Network for Plant Conservation, Canberra.

For more information and to order, go to <http://www.anpc.asn.au/publications/translocation.html>

Research round up

Compiled by Kirsten Cowley

Centre for Plant Biodiversity Research, Canberra. Email: Kirsten.Cowley@csiro.au

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Research round up

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Contributions to Research Roundup are welcome, and should be sent to Kirsten Cowley at the above email address using an email subject heading "APC Research Roundup" or similar. Their inclusion will be subject to available space.

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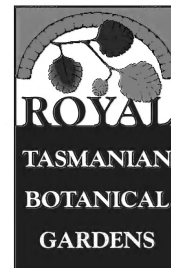
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KEYNOTE SPEAKER:

Professor Ian Lunt,
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PLENARY SPEAKERS:

Professor David Bowman,
University of Tasmania

Dr Terry Walshe,
Australian Institute of
Marine Science

Professor Jonathon Majer,
Curtin University

Andrew Smith, Tasmanian Parks
and Wildlife Service

Photos (left to right): *Tetratheca gunnii*, a
Tasmanian endangered species; *Richea scoparia*,
an abundant alpine plant endemic to Tasmania.
Photos: Royal Tasmanian Botanical Gardens